The University of Maine's floating VolturnUS wind turbine prototype is anchored off the coast of Castine, Maine. *Image courtesy of the University of Maine*

Wind Energy Becomes Nation's Number-One Renewable Generation Capacity

Letter from the Wind Office Director

This spring edition of the U.S. Department of Energy (DOE) Wind Research & Development Newsletter comes on the heels of a milestone year for the wind industry. In 2016, the industry surpassed 82,000 megawatts (MW) of total installed capacity to make wind the number-one source of renewable generation capacity in the United States. In December 2016, developer Deepwater Wind began operating America's first offshore wind farm: the Block Island Wind Farm, a five-turbine, 30-MW project located off Rhode Island. The Amazon Wind Farm—North Carolina's first utility-scale wind project—came on line in

DOE Demonstration Projects Improve Commercial-Scale Offshore Wind Manufacturing

Energy consumption in the coastal states amounts to roughly 80% of the U.S. electricity demand, making offshore wind a crucial aspect of the country's clean energy mix. Since 2012, DOE has supported a portfolio of advanced wind energy technology demonstration projects representing some of the nation's most innovative offshore wind projects in state and federal waters—including expediting the design process for

IN THIS ISSUE

To receive this newsletter by email or to sign up for breaking news on funding opportunities and other topics, go to the Wind Energy Technologies Office's website. *energy.gov/eere/wind/news*

Wind Energy Becomes Nation's Number-One Renewable Generation Capacity

Letter from the Wind Office Director *continued from page 1*

February 2017, bringing the number of states with utility-scale wind power installations to 41.

We're also excited by the future leaders of the wind industry. Last month, Penn State took home their third Collegiate Wind Competition prize by winning the 2017 Collegiate Wind Competition Technical Challenge, hosted at the National Wind Technology Center outside Boulder, Colorado.

This year, the Wind Energy Technologies Office celebrated the 2-year anniversary of DOE's historic *Wind Vision Report*, which quantified the economic, environmental, and social benefits of a future where wind powers up to 35% of the nation's electrical demand by 2050. Guided by the *Wind Vision*, DOE's investments support energy science research and development activities that enable technological innovation to improve the performance and lower the cost of wind energy technologies.

In just 2 years, DOE has supported a number of projects making dramatic progress toward this goal, including deploying two research buoys that measure weather and oceanographic data; funding the Hexcrete Tower, which uses prefabricated concrete components to develop a taller turbine tower; and utilizing 3-D printing for the fabrication of wind turbine blade molds.

One new example of innovation being explored by the Energy Department is self-flying drones, which can quickly inspect an entire field of wind turbines in minutes—a process that, when done manually, can take months. SkySpecs, an Ann Arbor, Michigan-based startup, designed autonomous drones programmed with an advanced damage-identification system that captures high-quality images, detects wind turbine cracks, and collects valuable data about turbine damage and defects.

José Zayas,
Director, Wind Energy Technologies Office

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Under the Atmosphere to Electrons (A2e) research initiative, the National Renewable Energy Laboratory and Sandia National Laboratories (Sandia) are conducting experiments in yaw-based wake steering control strategies. Wind plants sacrifice up to 20% of their gross energy to wake losses, or weaker, turbulent winds created by upstream turbines. Yaw-based wake steering can turn upstream turbines away from the wind inflow, decreasing the overall efficiency loss.

Finally, if you want to learn more about the Wind Energy Technologies Office's research and development project portfolio, visit our new interactive map located at *https://www.energy.gov/eere/wind/ wind-energy-technologies-office-projects-map*

Thank you for joining me in celebrating the accomplishments we're making together to promote the power of wind.

The Office has a lot going on here at American Wind Energy Association (AWEA) WINDPOWER 2017 (please see p. 4 of this newsletter for a schedule of DOE-related events). Come see us at DOE's booth #3436 to meet DOE representatives and pick up the latest publications.

Sincerely,
José Zayas
Wind Energy Technologies Office Director
U.S. Department of Energy

commercial-scale foundation manufacturing and developing offshore wind turbine foundations that reduce installation time and costs. These projects are intended to address key challenges associated with installing full-scale offshore wind turbines, connecting offshore turbines to the power grid, and navigating new permitting and approval processes.

After making significant progress on engineering and project development activities, DOE onboarded Lake Erie Energy Development Corporation's (LEEDCo's) Icebreaker project and the University of Maine's New England Aqua Ventus I into the Advanced Technology Demonstration Program for Offshore Wind in May 2016.

The University of Maine has demonstrated a 1:8-scale prototype of their floating VolturnUS foundation—a concrete semisubmersible structure that has been scaled up to support a 6-MW direct-drive turbine. Two of the VolturnUS platforms are planned to be deployed in deep waters off the coast of Monhegan Island, Maine. Using knowledge gained during the prototype stage, the university and its partners have focused on commercial-scale manufacturing of the full-scale foundation, which has resulted in increased design efficiency by reducing the internal steel requirements and improving the manufacturability of the foundation.

LEEDCo plans to install six 3.45-MW direct-drive turbines in Lake Erie, 8 miles off the coast of Cleveland, Ohio, for its Icebreaker project. After significant engineering analysis, LEEDCo selected Mono Bucket foundations to support the turbines, which will not require pile driving. This innovative foundation concept is expected to reduce installation time, costs, and environmental impacts in both the Great Lakes region and in offshore applications off the Atlantic and Gulf Coasts.

Atmospheric Conditions Drive Turbine Wake Behavior at Sandia National Laboratories

Results recently acquired from the Wake Steering Experiment being conducted at the Sandia Scaled Wind Farm Technology (SWiFT) facility located near Lubbock, Texas, vividly demonstrate the impact of atmospheric conditions on the behavior of wind turbine wakes. Using a unique scanning lidar from partners at the Technical University of Denmark, researchers measured the velocity profile of the SWiFT wind turbine wake at numerous downstream distances ranging from 27 to 135 meters (m) (1–5 rotor diameters) under different inflow conditions.
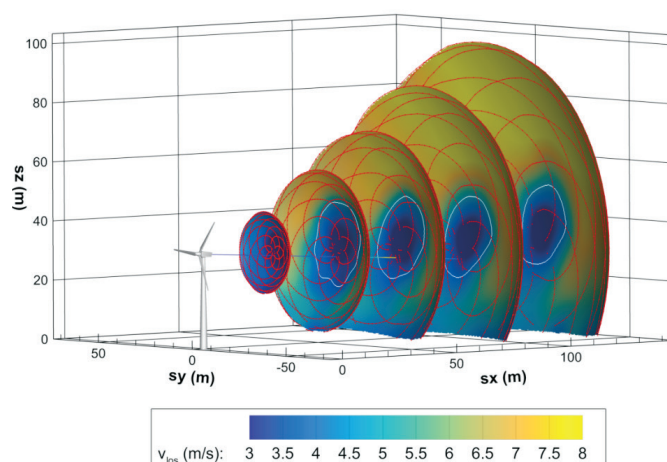
Configuration of the SWiFT turbine with the lidar measuring the downstream velocity. The yellow portion of the laser schematic depicts probe volume. *Image courtesy of Sandia National Laboratories*

Developing turbine control strategies that successfully optimize plant power production and minimize damaging turbine loads requires a full understanding of the link between atmospheric conditions and wake behavior. One large driver of wind is the daily cycle of the sun rising and setting, causing heating and cooling of the Earth's surface and the adjacent air. Daytime heating causes more mixing of the air from the ground up, creating an unstable atmosphere. As the sun sets, the mixing reduces and the atmosphere stabilizes. These two conditions dramatically affect the flow through a wind plant, creating different effects on wind turbine wakes.

Animations created from velocity scans of the turbine wake at 81 m downstream show how unstable atmospheres cause dramatic shifts in the wake, unlike stable atmospheres, wherein the wake appears locked in place.

Other velocity scans show that positive or negative veer—or the change in wind direction with height—can cause the wake to skew in one direction or the other.

These atmospheric changes greatly impact the wind power plant's downstream turbines—and understanding their effect is essential for plant optimization.

"The high-resolution, open-access data currently being collected on wakes at the SWiFT facility will help improve not only our high-fidelity computational tools, but also the tools used across the wind industry to design and deploy more efficient wind plants," says David Maniaci, the aerodynamics and verification and validation lead at Sandia.

DOE Wind Energy Technologies Office Presentations at AWEA WINDPOWER 2017

TUESDAY May 23	**Wind Curtailment and the Value of Transmission under a Wind Vision Future** 12 p.m.–12:25 p.m. **Jennie Jorgenson**, *Engineer, National Renewable Energy Laboratory*
	Workforce for the Future of Wind 1 p.m.–2 p.m. **Suzanne Tegen**, panelist, *Wind Power Deployment Manager, National Renewable Energy Laboratory*
	Project Threats…Inside Job? 2:15 p.m.–3:15 p.m. **Suzanne Tegen**, panelist, *Wind Power Deployment Manager, National Renewable Energy Laboratory*
	Collegiate Wind Competition (CWC) Mixer 4:30 p.m.–5:30 p.m. U.S. Department of Energy Booth #3436 Stop by the DOE booth during Tuesday's Exhibition Reception, meet CWC staff, and learn about the upcoming 2018 competition! Join us as we celebrate the future leaders of wind energy.
WEDNESDAY May 24	**Bulk Power System Energy Prices at Very High Wind Penetrations—Will Energy-only Markets Work?** 2 p.m.–2:25 p.m. **Michael Milligan**, *National Renewable Energy Laboratory*
	Wind Cost and Performance Improvements: Where Have We Been, Where Are We Going? 3 p.m.–3:25 p.m. **Ryan Wiser**, *Senior Scientist, Lawrence Berkeley National Laboratory*
	Trends, Opportunities, and Challenges for Tall Wind Turbine Tower Technologies 3:30 p.m.–3:55 p.m. **Eric Lantz**, *Senior Energy Analyst, National Renewable Energy Laboratory*
	Poster Reception 4:30 p.m.–6 p.m. Deployment of Wind Turbines in the Built Environment: Risks, Lessons, and Recommended Practices **Ian Baring-Gould**, *Technology Deployment Manager, National Renewable Energy Laboratory* Forecasting the Future of Distributed Wind, Opportunities and Challenges for Behind-the-Meter Projects **Eric Lantz**, *Senior Energy Analyst, National Renewable Energy Laboratory* Fully-Coupled vs. Sequentially Coupled Loads Analysis for Offshore Wind Turbines **Rick Damiani**, *Senior Engineer, National Renewable Energy Laboratory*
THURSDAY May 25	**The Power of R&D as a Means for Continued Growth in a Post-PTC World** 11:30 a.m.–11:55 a.m. **Trieu Mai**, *Senior Energy Analyst, National Renewable Energy Laboratory*

Data from the Wake Steering Experiment will be used to calibrate and validate computational models, leading to greater knowledge of the wind flow into and through the wind plant. This knowledge can be used to forecast winds, leading to improved performance of current and future wind plants and reducing the cost of energy. A 3-hour sample set of inflow, turbine, and lidar data acquired at 67.5 m downstream that shows the inflow transition from an unstable to neutral atmosphere is now publicly available on the DOE A2e Data Archive and Portal located at: *https://a2e.energy.gov/projects/wake*

New Public Siting Tool Addresses Potential Impacts of Wind Turbines on Radar Systems

As part of DOE's effort to address and remove siting barriers for wind energy developments, Sandia has partnered with the National Oceanic and Atmospheric Administration
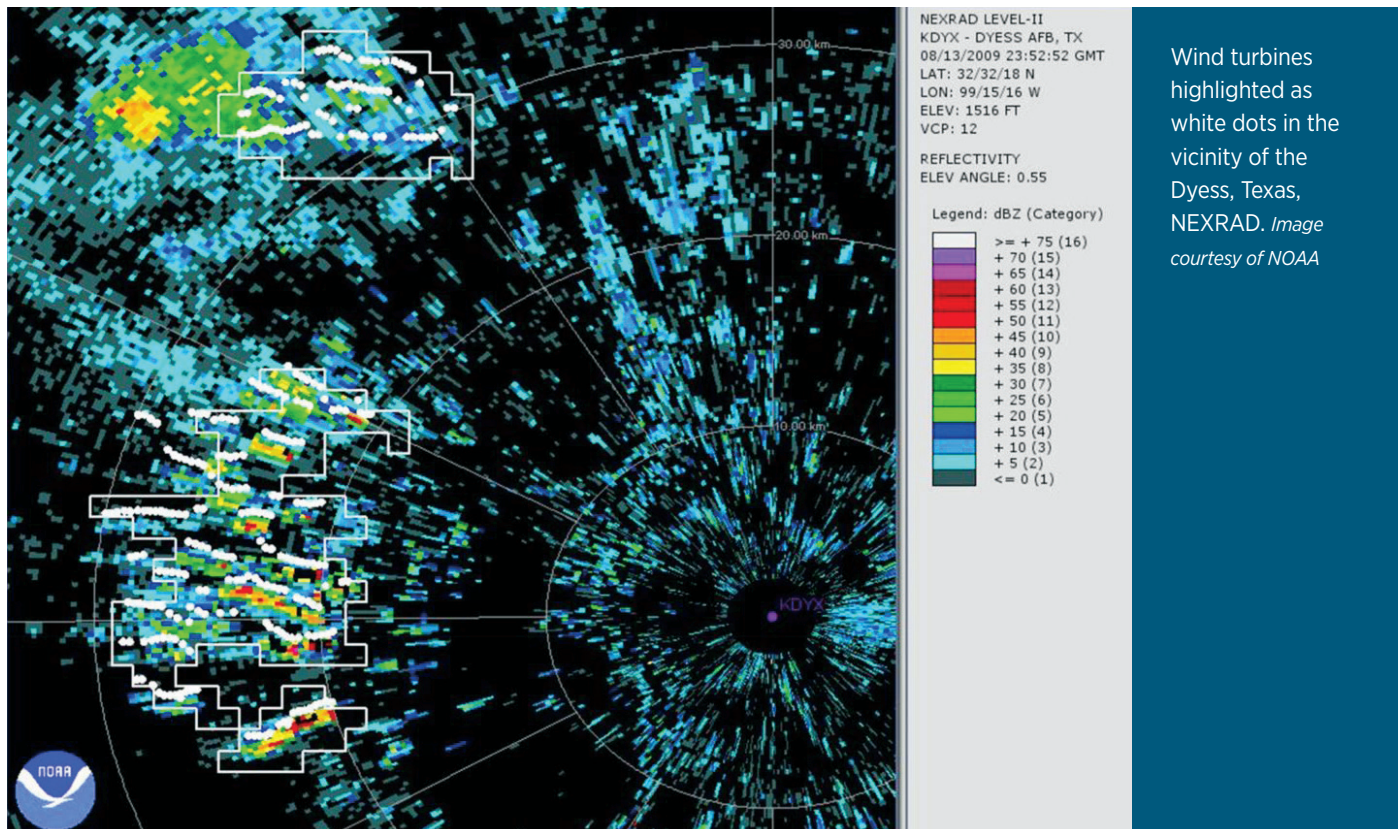
(NOAA) to develop the first publicly available geographic information system (GIS) addressing the potential impacts that wind turbines can have on radar systems—such as impacting weather forecasts and NOAA's severe weather warning system.

Because Next-Generation Radar (NEXRAD) systems detect wind turbines as they rotate, wind farms can negatively impact weather forecasts and severe weather warnings. NOAA, DOE, and Sandia have developed a screening tool for wind developers, which will obtain a preliminary review of possible weather radar impacts prior to an official Obstruction Evaluation/Airport Airspace Analysis filing. This public tool was developed in part through a strategic partnership project with NOAA and is based on Sandia's Tool for Siting, Planning, and Encroachment Analysis for Renewables.

NOAA forecasters primarily use NEXRAD—technically known as Weather Surveillance Radar-1988 Doppler—to track weather and make immediate severe weather warning
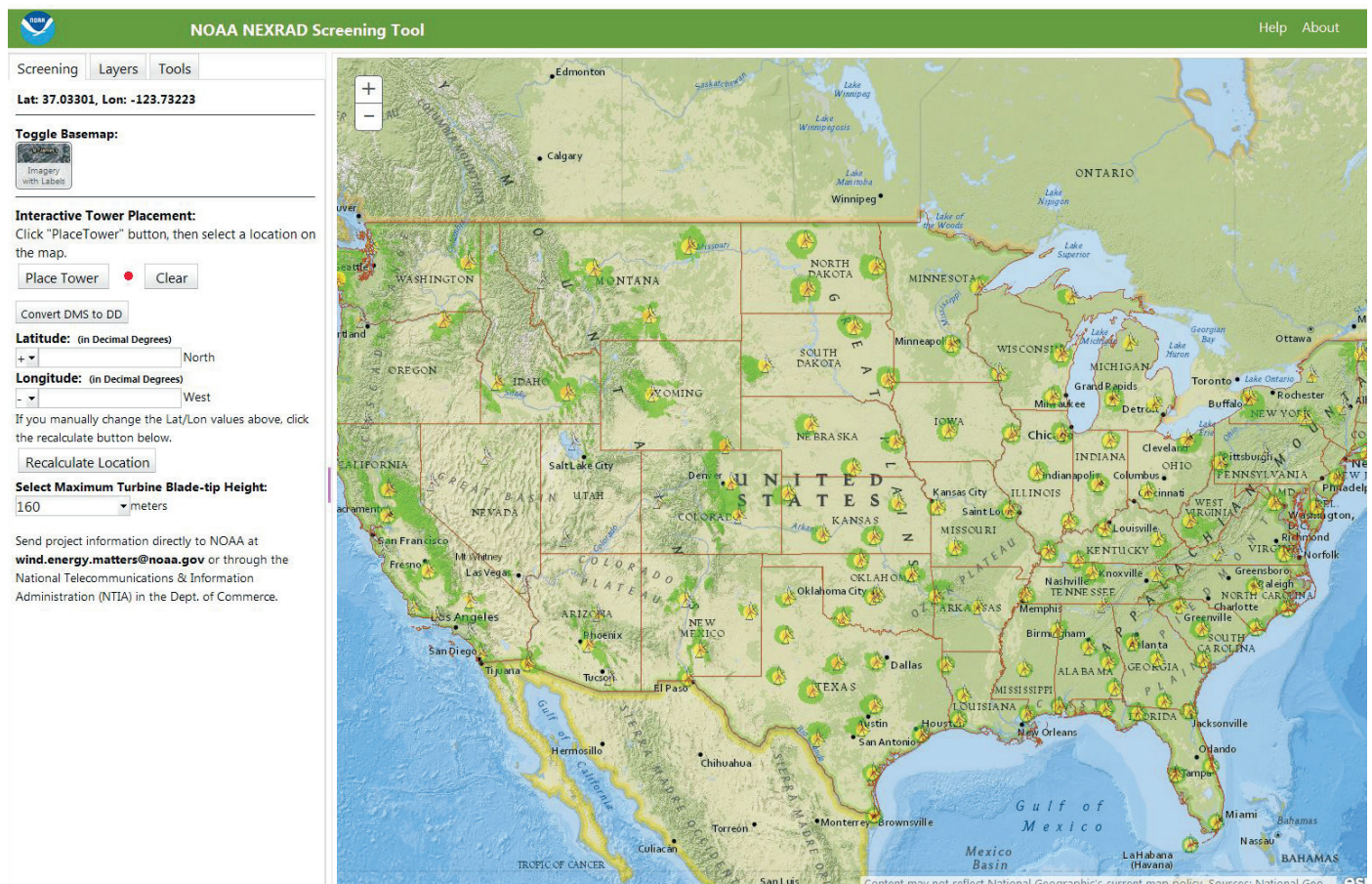
Screenshot of NOAA NEXRAD Screening Tool home page. This shows a high-level view of the continental United States with all the NEXRAD systems and their corresponding viewsheds for a default height of 160 m. *Image courtesy of NOAA*

NEXRAD LEVEL-II
KDYX - DYESS AFB, TX
08/13/2009 23:52:52 GMT
LAT: 32/32/18 N
LON: 99/15/16 W
ELEV: 1516 FT
VCP: 12

REFLECTIVITY
ELEV ANGLE: 0.55

Legend: dBZ (Category)

>= + 75 (16)
+ 70 (15)
+ 65 (14)
+ 60 (13)
+ 55 (12)
+ 50 (11)
+ 45 (10)
+ 40 (9)
+ 35 (8)
+ 30 (7)
+ 25 (6)
+ 20 (5)
+ 15 (4)
+ 10 (3)
+ 5 (2)
<= 0 (1)

Wind turbines highlighted as white dots in the vicinity of the Dyess, Texas, NEXRAD. *Image courtesy of NOAA*

decisions that directly impact public safety. NEXRAD data also support operations of the Federal Aviation Administration's National Airspace System, U.S. Department of Defense, other government agencies, private industry, and the public.

Users of the online GIS NOAA NEXRAD Screening Tool can place proposed wind turbines at user-selected locations on the map, choosing the turbine's blade-tip height to visually identify if that turbine is within a defined NOAA weather radar impact zone. The GIS tool provides users with basic measurement and drawing tools to assist with project prospecting and siting.

Also available are NOAA's NEXRAD and Terminal Doppler Weather Radar zone definitions, NOAA's "NEXRAD Wind Farm Impact Zone Maps and the Radar Operations Center Evaluation Process" document, and various mapping features—including the NEXRAD radars, the Terminal Doppler Weather Radars, the latest version of the U.S. Geological Survey Wind Turbine Database, and a few basic public mapping layers.

This tool provides first-level feedback to developers and NOAA points of contact who can further analyze impacts and mitigation efforts on NEXRAD weather radars. The use of this tool does not replace the official Federal Aviation Administration process, but rather aids in planning to streamline that process.

In addition to the publicly available tool, current work is underway to develop a NOAA-only tool to replace their existing screening tool, which will be completed by the end of May 2017.

For more information, visit *http://energy.sandia.gov/energy/ renewable-energy/wind-power/wind-turbine-siting-and- barrier-mitigation/* and *https://www.roc.noaa.gov/WSR88D/ WindFarm/WindFarm.aspx*

Gearbox Reliability Collaborative Successfully Demonstrates a Longer Gearbox Lifetime

DOE's National Renewable Energy Laboratory (NREL) has successfully demonstrated a new gearbox design developed by the Gearbox Reliability Collaborative

The GRC-developed Gearbox 3 was designed by Romax Technology, Powertrain Engineers, and The Timken Company and was manufactured and assembled by Brad Foote Gearing. *Photo by Jonathan Keller, NREL 36525*

(GRC), with a predicted lifetime 3.5 times greater than the previous, conventional design. NREL established the GRC in 2007 to address the failure of many wind turbine gearboxes in achieving their intended design life, despite meeting then-current design standards and third-party certification criteria.

The GRC analyzed the root causes of premature gearbox failures and confirmed that most of them were caused by an underestimation of loads and the absence of critical elements in the design process. The new gearbox design addresses the load issue, but the GRC has yet to address an unusual failure mode experienced by wind turbine gearboxes, called bearing axial (or "white etch") cracking.

To address the gearbox loads, the GRC combined gearbox testing, modeling, and analysis of a 750-kilowatt drivetrain. The team built two gearboxes with conventional cylindrical roller bearings in their planetary section, and tests showed that rotor nontorque loads would not be shared effectively among the roller bearings, that high-torque conditions would reduce the fatigue life, and that skidding could occur in low-torque situations, potentially leading to premature bearing failure.

To address these issues, a new gearbox, called Gearbox 3, was designed using preloaded tapered roller bearings in the planetary section. The new gearbox design demonstrated improved planetary load-sharing characteristics in the presence of rotor pitch and yaw moments, resulting in a predicted gearbox lifetime that is 3.5 times greater than the previous, conventional design. See a report summarizing the work at *http://www.nrel.gov/docs/fy17osti/67394.pdf* and the GRC website at *https://www.nrel.gov/wind/grc.html*

However, the GRC still needs to address the problem of bearing axial cracking. The inner ring of the bearing can suffer a crack that aligns with the axis of rotation of the shaft on which it is mounted. Such a crack can actually split the inner ring in two. The failure mode also happens in other industries, but much less often and with lower costs to replace, so in many design processes this potential failure is essentially ignored.

"We're trying to understand why it occurs so frequently in wind as compared to other industries," says Jonathan Keller, NREL's principal investigator for the project. "So we're leading the charge to understand this failure mode and design it out of the gearbox."

The GRC brings together wind turbine manufacturers, owners, suppliers, researchers, and consultants to develop improved processes for the design, testing, and operation of wind turbines to increase gearbox reliability. The GRC includes major wind turbine manufacturers, including GE Renewable Energy, Siemens, and Vestas Wind Systems, as well as wind project developers such as MidAmerican Energy Company, Iberdrola, and NextEra Energy Resources. With the GRC nearing its tenth anniversary, wind farm operators report significant improvements in gearbox reliability, with the mean time between failures increasing from 5 years to 8–12 years.

Leading-Edge Erosion Research Used to Reduce Wind Power Plant Performance Uncertainty

Severe wind turbine blade leading-edge surface erosion can cause increased wind turbine performance losses that are far greater than anticipated during wind plant development.

Example of a blade with severe leading-edge erosion (left), a blade leading edge with observed field roughness (middle), and a wind tunnel model with distributed roughness elements (right). *Photo by Zachary Finucane, Keystone Engineering*

"For many wind plants, leading-edge erosion is the largest source of maintenance costs for blades," says Josh Paquette, who leads Sandia's Blade Reliability Collaborative. Sandia's leading-edge erosion research project team recently completed several project phases, uncovering several effects of blade erosion and roughness—including a potential reduction of annual energy production of more than 5% for a utility-scale wind turbine. The experimental data and roughness model generated as part of this project will be used to reduce the uncertainty of the impact of leading-edge erosion on wind power plant performance predictions, optimize blade maintenance cycles, and develop more robust blade designs.

Researchers used a profilometer to measure blade surface roughness and erosion at an operational utility-scale wind farm during the project's first phase of work. A computational model, developed with partners at University of California Davis, captured the effect of roughness and erosion on airfoil transition and performance characteristics.

In the second phase of the research, the research team compared the model results to the experimental results of the S814 airfoil from the Texas A&M Oran W. Nicks

Low Speed Wind Tunnel, which established the model's reliability for tip and midspan airfoils. An airfoil with nominal field roughness performs better than an airfoil with transition tape, often used in airfoil experiments to force airflow transition to occur abruptly near the blade's leading edge.

The reports and associated data will be released in early June through the A2e Data Archive and Portal at *https://a2e.energy.gov/about/dap*

How the Wind Blows: Pacific Northwest National Laboratory Research Informs Wind Forecasting Models

The variability of wind energy is viewed by some as a hindrance to achieving greater integration with the electrical grid. And even though we cannot control when the wind blows, we can certainly get better at predicting it.

As part of DOE's Wind Forecasting Improvement Project, the Pacific Northwest National Laboratory (PNNL) led a team of scientists—including researchers from Nanjing University and Lawrence Livermore National Laboratory—in studying the effect of different variables in forecasting wind speed and power at turbine hub

Accurate wind forecasting is essential to optimizing weather models. Scientists at PNNL worked with partners to study the effect of different variables in forecasting wind speed and power at turbine hub heights. *Photo by Joshua Bauer, NREL 38020*

heights. By using a range for factors like turbulence and surface roughness, as opposed to considering them constants, the team found that the electricity generated by wind turbines could range from 20% to 100% of their rated power during select time periods, depending on the variables chosen. In other words, current models exclude some key variables, potentially causing wind farm operators to miss out.

For wind farm operators, the accuracy of forecasts is critical. Wind forecasting goes beyond simply predicting when it will blow and when it won't. Wind forecasting involves calculating how much energy will be produced, and a lot of factors—such as speed, direction, shear, duration, and time and spatial scales of a wind power plant—go into assessing the energy output of an upcoming wind event. If forecasts are off, wind farm operators lose money by either not delivering the power they promised (forecast winds did not materialize) or producing more

energy than the power grid can accept (forecast winds were stronger than anticipated).

"Running a wind farm isn't as simple as turning the turbines on when it's blowing and turning them off when it's not," says Larry Berg, atmospheric and global change scientist at PNNL. "Operators and utilities need to carefully coordinate supply and demand. By improving the models operators use to predict both wind speed and wind power, we can increase the level of wind power on the grid."

To maximize production, wind farm operators rely heavily on forecasting models and simulations that take into account fine-resolution variables. The accuracy and sensitivity of these models directly affect wind energy production, essentially telling operators how much energy could be produced under certain conditions.

Wind speeds change multiple times within an hour and vary wildly based on turbine height, making it difficult to forecast energy outputs. In addition, wind farms are often placed in areas of complex terrain, where hills and valleys channel the wind and make it more turbulent, adding another layer of complexity to predicting wind speeds. Weather models do not currently handle complex terrain well—and one of the constants in the models is the topography of the land.

The PNNL-led team discovered the models' missing variables by using formal uncertainty quantification techniques—a research method that attempts to determine the likelihood of an outcome when certain variables are not known—in conjunction with the Weather Research and Forecasting (WRF) model, a popular process and prediction meteorological model. The team investigated the WRF model response to changes in the values of specific constants and identified which model parameters have the largest influence on the simulated wind speed and potential wind power. To verify the accuracy of the model, they compared the simulation results to data collected in the spring as part of the DOE-supported Columbia Basin Wind Energy Study.

The next step is to extend the analysis to the summer, fall, and winter seasons and apply the techniques to alternate boundary-layer parameterizations commonly used in the WRF model. The results of this work will guide model development for continued improvement in tracking wind energy, designing field studies, and integrating wind energy into the power grid.

The results of the study can be read in the scientific journal *Boundary-Layer Meteorology* at *http://link. springer.com/article/10.1007%2Fs10546-016-0185-2*

Empowering Small Businesses to Expand Wind Energy Innovation

DOE's Office of Energy Efficiency and Renewable Energy (EERE) recognizes the critical role public-private partnerships play in accelerating the transition to a clean energy economy. American small businesses continue to drive job creation and economic growth. Fueled by the spirit of innovation, invention, and entrepreneurship, they are a backbone of the U.S. economy and have a tremendous opportunity to help America lead the clean energy race.

EERE is putting the world-class resources of the national laboratories at the fingertips of many energy startups with the Small Business Vouchers (SBV) Pilot, in which selected small businesses will address clean energy technologies in nine technical areas: advanced manufacturing, bioenergy, buildings, fuel cells, geothermal, solar, vehicles, water, and wind. Additionally, the second round introduced three new national labs to the program who have already partnered with businesses.

The Wind Energy Technologies Office awarded funding for three small businesses to collaborate with two national laboratories to focus on ways to maximize blade life (Sentient), build taller wind towers (Wind Tower Tech), and optimize wind farm performance and lifespan (WindEsco). This collaboration will help these energy startups to address clean energy technologies in wind energy innovation.

The SBV Pilot provides U.S. small businesses with unparalleled access to the expertise and facilities of its national laboratories. Over three rounds, the Energy Department has offered up to $20 million to support approximately 100 small businesses by issuing national lab vouchers valued between $50,000 and $300,000 per company.

SBV is part of the Tech-to-Market Program within EERE. Tech-to-Market is focused on strengthening the innovation ecosystem by eliminating common barriers that prevent market exploration of new energy technologies. To learn more about SBV and current projects, visit *www.SBV.org*

A view of a blade mold section showing the unique ducting that allows for a more efficient curing process. *Photo courtesy of Oak Ridge National Laboratory*

Additive Manufacturing of Wind Blade Molds Projects to Save Time and Reduce Costs

A partnership between DOE's Oak Ridge National Laboratory (ORNL), Sandia, and private company TPI Composites recently demonstrated the significant time- and cost-saving potential of integrating additive manufacturing techniques, also known as 3-D printing, into wind turbine tooling.

Traditionally, manufacturing a wind blade mold involves creating a physical model—or plug—of the blade, coating the plug with fiberglass to create a mold, running miles of wire through the mold to heat it and cure the resins, and making final adjustments to ensure the mold is within specification. A blade is one of the most expensive and time-consuming wind turbine components to manufacture, and that cost is rising as demand for larger blade sizes grows.

Additive manufacturing eliminates the need for the plug, and building ducts into the mold's design allows manufacturers to cure the mold's fiberglass finish with hot air, eliminating the need for wiring.

"The process reduces the time to manufacture the molds by reducing complexity. We demonstrated that the process could be accomplished in weeks rather than months with lower projected costs," says Lonnie Love, corporate fellow and leader of the Manufacturing Systems Research group at ORNL.

Researchers printed the mold at DOE's Manufacturing Demonstration Facility at ORNL using Cincinnati Incorporated's Big-Area Additive Manufacturing platform. The 13-m blade mold was printed in eight sections of about 2 m each.

ORNL used acrylonitrile butadiene styrene (ABS) polymer reinforced with 20% carbon fiber by volume for the first 3-D-printed blade mold. The ABS material, which costs around $4–$5 per pound, is the "workhorse" for ORNL's additive manufacturing research. Love also notes that integrating other materials such as glass fiber could cut those costs in half. The lab has also been researching the use of bio-based materials in additive manufacturing, such as bamboo and other wood composites.

When testing the mold's hot air curing process, researchers were challenged with the ABS polymer's anisotropic properties. (In this case, the thermal expansion is different in different directions.) However, because the mold was overlaid with fiberglass, it mitigated this problem. "The fiberglass coating's long fibers stabilized the part," Love said. The ORNL engineers are leveraging this knowledge as they continue to research large-scale additive manufacturing.

Reducing the cost of blade molds can also encourage more creativity in blade design. "It was one of our main motivations in the project," Love says. Having that flexibility could lead to advancements in blade design that improve the efficiency of a wind plant.

Researchers give perspective to the size of the assembled wind blade mold at DOE's Manufacturing Demonstration Facility at ORNL. *Photo courtesy of Oak Ridge National Laboratory*

Wind Industry Events

Small Wind Turbine Design & Construction
Custer, Wisconsin
June 9–14, 2017

The Energy Fair
Custer, Wisconsin
June 16–18, 2017

AWEA Wind Resource & Project Energy Assessment Conference 2017
Snowbird, Utah
September 27–29, 2017

North American Society for Bat Research Meeting
Knoxville, Tennessee
October 18–21, 2017

AWEA Offshore WINDPOWER 2017
New York City, New York
October 24–25, 2017

AWEA Wind Energy Fall Symposium 2017
Albuquerque, New Mexico
November 7–9, 2017

Stay current on important wind energy events around the nation by receiving the Wind R&D Newsletter in your email. Subscribe at *energy.gov/eere/wind/news*.